Indirect Reduction with Sliding Compression Screw Stabilization for Subtrochanteric Fractures

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Background: Subtrochanteric fractures possess unique characteristics, and no single device used in their treatment is considered absolutely superior to others. Use of sliding compression screws (SCSs) is technically simple. The feasibility of SCS stabilization was evaluated using indirect reduction of fracture fragments.

Methods: One hundred and thirty-one acute subtrochanteric fractures without extensive shaft involvement were treated using this technique, and they were classified into 4 groups to evaluate the success rate. After the lag screw was inserted into the femoral head, the side plate was applied onto the distal fragment without exploring the fracture site. At least 4 cortical screws were used to stabilize the distal fragment. Postoperatively, ambulation with protected weight bearing was encouraged at as early a time as was possible.

Results: One hundred and thirteen fractures were followed-up for 12~38 (mean, 22) months. The union rate was 94.7% (107/113), and the time period until union occurred was 2.5~8 (mean, 3.8) months. No statistical difference was noted among the individual groups. Complications included 6 nonunions (5.3%), which were associated with infection in 1 case (0.9%) and implant failure in 2 cases (1.8%).

Conclusions: Compared to other techniques, indirect reduction with SCS stabilization is a feasible method for treating acute subtrochanteric fractures. However, because plate insertion normally requires a large dissecting wound and biomechanically the tension band principle might not be applicable, there may be greatly increased complications with extensively comminuted fractures. Accordingly, if this technique is used for carefully selected fractures, a high success rate can be expected.

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Key words: indirect reduction, sliding compression screw, subtrochanteric fracture.

Traditionally, hip fractures included femoral neck, intertrochanteric, and subtrochanteric fractures. Clinically, subtrochanteric fractures are relatively uncommon.[1,2] Because of the nearly cortical quality of the subtrochanteric area the healing process with subtrochanteric fractures is relatively slow.

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Additionally, bending stresses can be large, and the bony contour is uneven. To the present, no single device has been judged to be absolutely superior to others.[1-4] Therefore, new devices continue to be developed, and success rates continue to rise.

Sliding compression screws (SCSs) have been used to treat intertrochanteric fractures for several decades, and high success rates have been reported.[5,6] In the literature, SCSs used to treat subtrochanteric fractures were reported to have achieved high success rates.[1,2] Technically, inserting SCSs is much simpler than inserting other types of implants. However, because a side plate is placed on the lateral cortex of the proximal femur, the large biomechanical torque produced by bending stresses often causes implant failure.[3,4] Various intramedullary devices have therefore been developed to reduce the lever arm of the bending stresses.[6,7] High success rates for these intramedullary devices have also been reported.[1-4]

While technical complications may occur during the learning period for inserting new devices, modifying the surgical technique of SCSs has also been tried.[1,2] Indirect reduction of fracture fragments and avoidance of compromising local vascularity may enhance fracture healing and reduce complications.[1,4,8] The purposes of this retrospective study were to evaluate the feasibility of indirect reduction of subtrochanteric fractures with SCS stabilization and to clarify the limits of its application. Then, it might be possible to recommend a simple technique for treating such difficult fractures.

METHODS

Between January 1998 and December 2003, 131 patients with 131 acute subtrochanteric fractures were treated with SCSs at our institution. Patients were aged 16~90 (mean, 54) years with a male to female ratio of 2 to 1. The causes of fractures included motor vehicle accidents (for most of the younger patients) and sliding down (for all of the elderly patients).[4] Fracture types were grouped by the Russell-Taylor classification and included 35 of type Ia, 29 of type Ib, 26 of type IIa, and 41 of type IIb.[1,2]

The emergency services first stabilized the vital signs. After systemic conditions were under control, the subtrochanteric fractures were treated at as early a time as possible. Patients with chronic medical disorders or associated with severe injuries were admitted. Fracture stabilization was performed after permission was received from related specialists. The period from the time of injury to fracture treatment was 0.3~14 (mean, 2.8) days.

Subtrochanteric fractures were treated by indirect reduction with SCS stabilization. Surgery was performed on a fracture table. The fracture site was approximately reduced by traction and manipulation. The lateral cortex of the greater trochanter was exposed. A lag screw (Synthes, Bettalach, Switzerland) was inserted with the tip 1 cm from the joint surface. Then, the distal fragment was exposed, but the fracture site was not touched. A side plate of sufficient length was applied. The side plate required the insertion of at least 4 cortical screws.[1,2] The screw hole on the side plate was left vacant if the medial cortex of the femur was comminuted, in order to avoid shortening the femur, because the fracture site might not be compressed by the side plate if the fracture was comminuted.

The indications for this technique included subtrochanteric fractures without extensive shaft involvement and an intact lateral cortex of the greater trochanter. For fractures with extensive shaft involvement, first- or second-generation nails were chosen, and those patients were excluded from this study. Nail devices were used for fractures with a comminuted lateral cortex, and those patients were also excluded from this study.[1,2]

After the operation, patients were permitted to ambulate with partial weight-bearing at as early a time as possible. Crutches or a walker were used until the fractures had healed. Exercises to increase the range of motion of the hip and the knee were encouraged. Patients were followed-up at the outpatient department (OPD) at 4~6-week intervals. The clinical and radiographic features of the fracture healing process were recorded. Complications were treated if necessary. After the fractures had healed, patients were advised to continue annual follow-up visits or whenever necessary.

We defined fracture union clinically as having no pain, tenderness, or need of aids to assist ambulation and radiographically as both fragments of the trabeculae having been connected.[6,9] Nonunion was defined as the fracture site still remaining unhealed after 1 year of treatment or the need for repeated surgeries to achieve union.[6,10]

For the convenience of comparison, Fisher's exact test or the 2-tailed unpaired Student's t-test was used. $p < 0.05$ was considered significantly significant.

RESULTS

One hundred and thirteen patients were followed-up for 12~38 (mean, 22) months. Eighteen patients were lost to follow-up despite our best efforts to contact them. One hundred and seven fractures had healed at 2.5~8 (mean, 3.8) months. The union rate was 94.7% (107/113).

In group Ia, 33 of 35 patients were followed-up. Thirty-one fractures had healed at 2.5~8 (mean, 3.7) months. The union rate was 93.9% (31/33). One nonunion was associated with a deep infection. The infection was treated with debridement and local antibiotics. The nonunion was treated with a local cancellous bone graft after the infection was well controlled. The nonunion had healed uneventfully by 7 months. The other nonunion was associated with plate breakage at 5 months. The nonunion was treated with SCS revision and bone cement augmentation. It had healed uneventfully by 4 months (Fig. 1).

In group Ib, 27 of 29 patients were followed-up. Twenty-six fractures had healed at 2.5~7.5 (mean, 4.1) months (Fig. 2). The union rate was 96.3% (26/27). The 1 nonunion had intact SCSs and was treated with a cancellous bone graft and bone graft substitutes. It had uneventfully healed by 3.5 months.

In group IIa, 22 of 26 patients were followed-up. Twenty-one fractures had healed at 2.5~6 (mean, 3.3) months. The union rate was 95.4% (21/22). The 1 nonunion had intact SCSs and was treated with a cancellous bone graft and bone graft substitutes. It had healed uneventfully at 4 months.

In group IIb, 31 of 41 patients were followed-up. Twenty-nine fractures had healed at 3~7.5 (mean, 3.9) months (Fig. 3). The union rate was 93.5% (29/31). One nonunion was associated with plate loosening and screw breakage at 7 months. It was

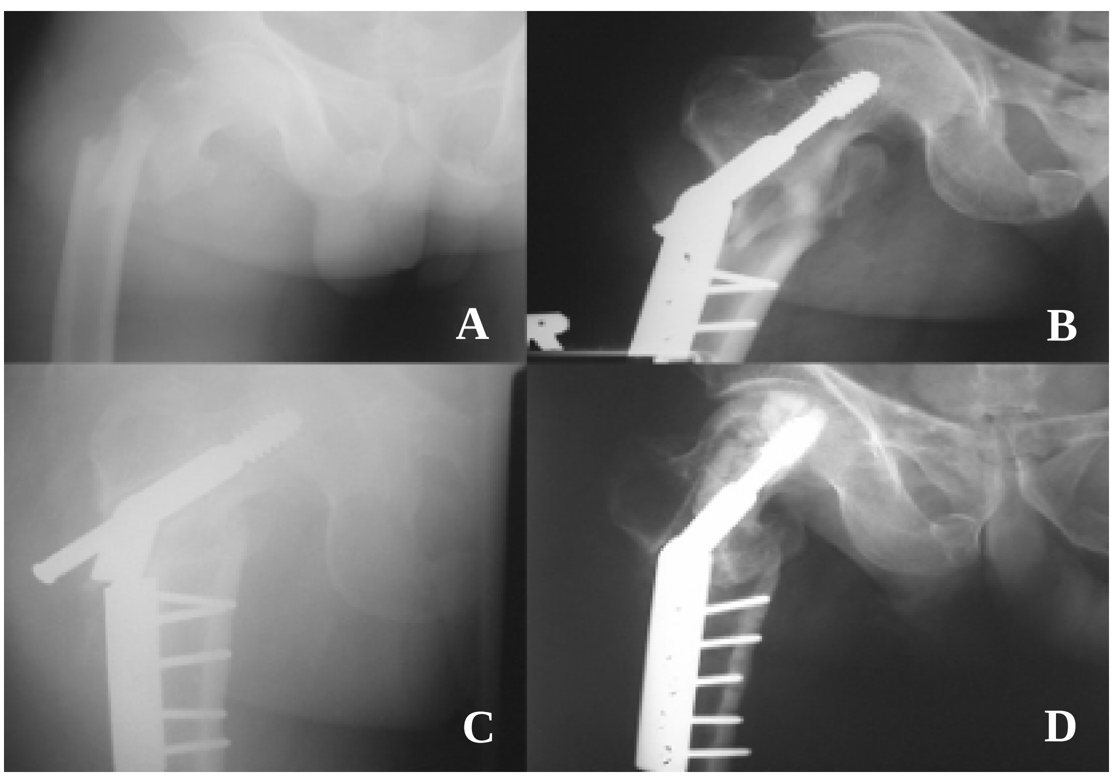

Fig. 1 A 79-year-old man sustained a right Ia subtrochanteric fracture due to sliding down (A). The fracture was treated by indirect reduction with sliding compression screw (SCS) stabilization (B). However, plate breakage occurred at 5 months (C). The nonunion was treated by SCS revision with bone cement augmentation; it had healed uneventfully at 4 months (D).

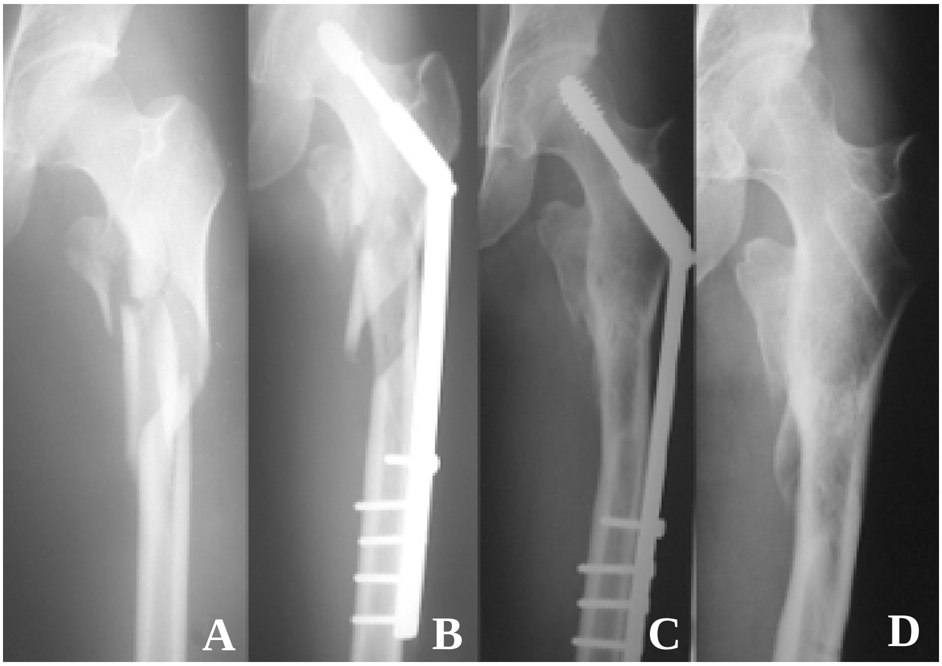

Fig. 2 A 46-year-old man sustained a left Ib subtrochanteric fracture due to a motor vehicle accident (A). The fracture was treated by indirect reduction with sliding compression screw stabilization (B); it had healed uneventfully at 4 months (C).The implant was removed at 1 year (D).

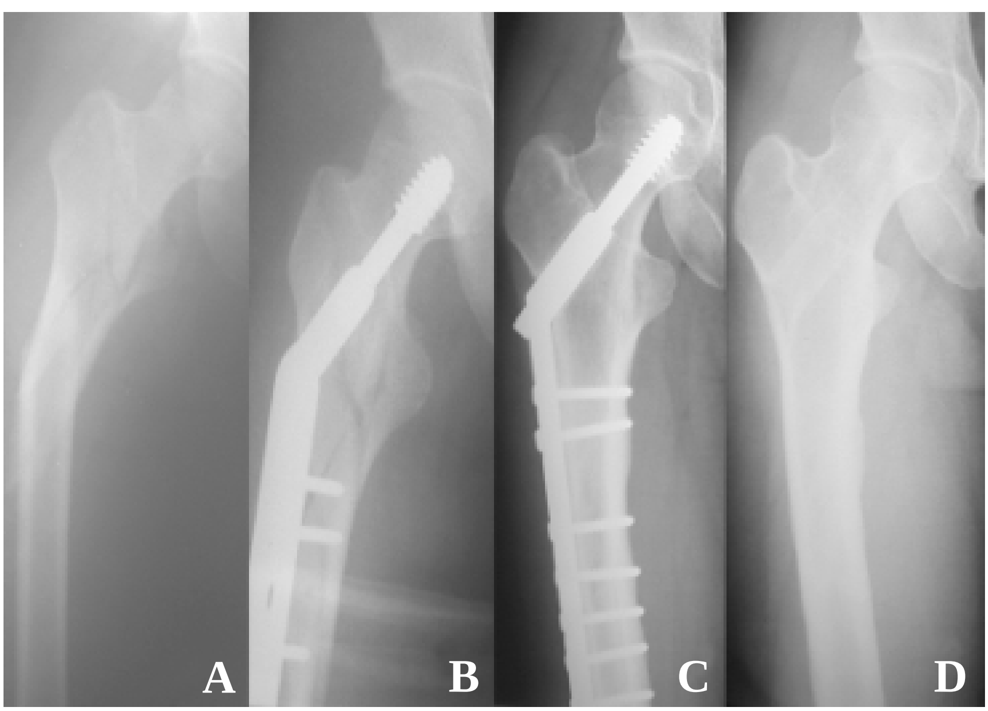

Fig. 3 A 77-year-old woman sustained a right IIb subtrochanteric fracture due to sliding down (A). The fracture was treated by indirect reduction with sliding compression screw stabilization (B). The fracture had healed uneventfully at 4 months (C). The implant was removed at 1 year (D).

treated with SCS revision and bone cement augmentation. The fracture had healed uneventfully at 4 months (Fig. 4) The other nonunion had intact SCSs and was treated with a cancellous bone graft and bone graft substitutes. It had healed uneventfully at 4.5 months.

In a comparison of groups I and II, the union rate was 95.0% vs. 94.3% (p = 0.36). The average union period was 3.9 $\pm$ 1.5 vs. 3.6 $\pm$ 1.3 months (p = 0.40).

In a comparison of stable (groups Ia and IIa) and unstable fractures (groups Ib and IIb), the union rate was 94.5% vs. 94.8% (p = 0.32), and the average union period was 3.5 $\pm$ 1.5 vs. 4.0 $\pm$ 1.3 months (p = 0.10), respectively.

In general, complications included 5.3% (4.4%, aseptic and 0.9%, septic) nonunions. There was no malunion (with angulation > 10°, rotational deformity > 10°, or shortening > 2 cm).[8,10]

DISCUSSION

Factors favoring fracture healing include a minimal gap, adequate stability, and a sufficient nutritional supply.[11] A subtrochanteric fracture is traditionally considered difficult to treat, and no single device is suitable for all of the various kinds of fractures encountered.[1-4] The subtrochanter possesses unique characters of a bulging contour and cortical quality, and is subjected to very large bending stresses.[12] These affect the early stability and later endurance of an implant. Clinically, nonunions with implant failure are not uncommon.[1-4] Therefore, an ideal surgical technique should provide sufficient stability and preserve local vascularity. In this study, the described technique met both of these demands for most of the subtrochanteric fractures encountered in this study.

The Russell-Taylor classification groups those pure subtrochanteric fractures as type I and sub-

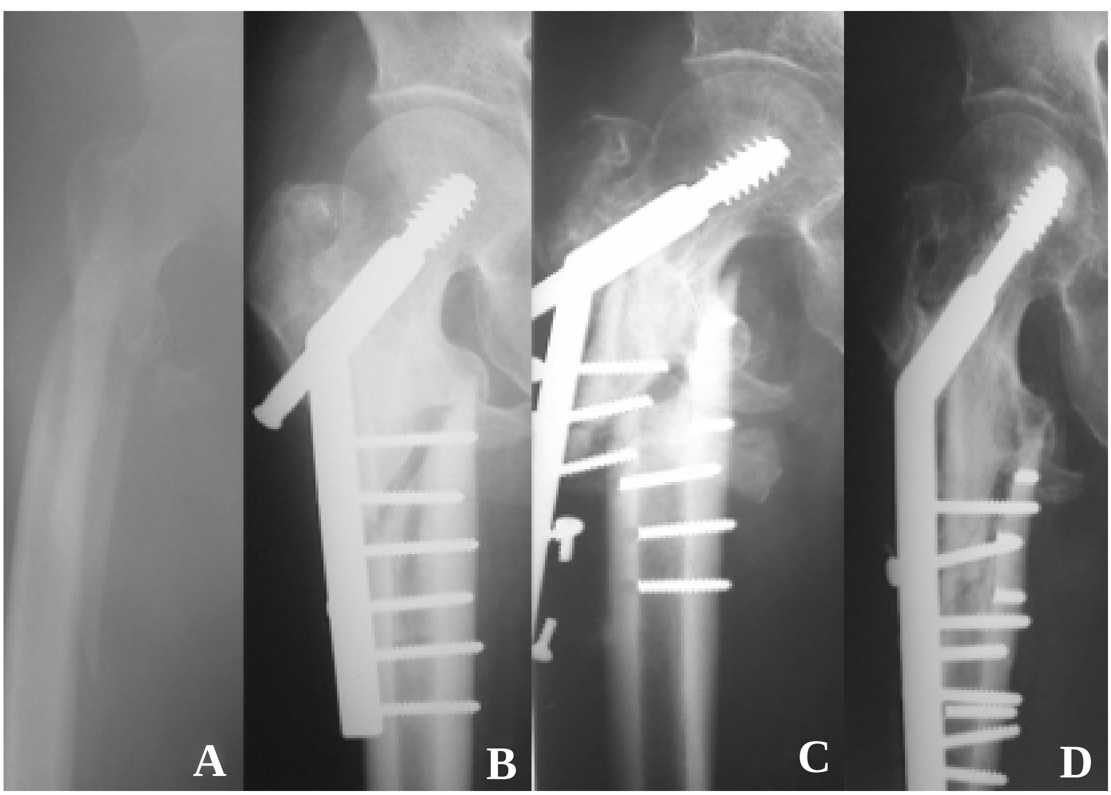

Fig. 4 A 71-year-old man sustained a right IIb subtrochanteric fracture due to sliding down (A). The fracture was treated by indirect reduction with sliding compression screw (SCS) stabilization (B). However, plate loosening with screw breakage occurred at 7 months (C). The nonunion was treated with SCS revision and bone cement augmentation. It had healed uneventfully at 4 months (D).

trochanteric fractures extending to the piriformis fossa as type II. The subgroups include involvement of the lesser trochanter (a) or a lack of it (b), which the local stability after an implant is applied.[1,2] For unstable fractures, the large bending stresses can induce implant failure (plate breakage or screw breakage) and fixation failure (plate loosening or fragment migration).[1-4,7] Therefore, strict restriction on weight bearing must be emphasized with SCSs to treat unstable subtrochanteric fractures.

Humans are bipedal animals. During the stance phase of the gait, the hip area sustains stresses of at least threefold the body weight.[3-7,13] The medial cortex is being compressed while the lateral cortex is being pulled.[3,7] To reduce the stresses on an implant, it is recommended that a plate be placed on the lateral cortex (the tension band principle).[1,27,14] Thus, the implant can be preserved for a longer time. However, to apply the tension band principle, the medial cortex must be intact after fragment reduction, or the bending stresses will break the plate.[3,7,14] For most subtrochanteric fractures, the medial cortex is normally comminuted, and abutment of the medial cortex is less possible. Therefore, strict restrictions on weight-bearing must be further emphasized. The high success rate in this series might should partially be attributed to patient compliance.

Advantages of indirect reduction of the fracture fragments have also been reported in treating other fractures.[8,15,16] It can reduce the incidence of infection while allowing fracture repair to continue. In the absence of fixation or implant failure, a high success rate is achievable for subtrochanteric fractures. In this study, a 94.7% union rate was achieved. This is even higher than with most intramedullary techniques.[1,2]

Various intramedullary devices have continued to be developed in efforts to remedy the disadvantages of a plate. High success rates for treating subtrochanteric fractures have also been reported.[1,2] However, each intramedullary device still has individual limits; thus, each may be unsuitable for a certain type of subtrochanteric fracture.[1-4] Zickel nails are strong devices but cannot prevent shortening of comminuted fractures.[17] The first generation of nails cannot be used in type II fractures due to intertrochanteric involvement.[12] Gamma nails are too short to be used in fractures with shaft involvement.[18] Long gamma nails or second-generation nails have advantages of a closed method and static stabilization.[19,20] Theoretically, either is suitable for all subtrochanteric fractures. In the literature, high success rates have been reported.

In the literature, plate treatment for femoral shaft fractures showed a relatively high complication rate.[21] However, currently, indirect reduction with plate stabilization is reported to have high success rates.[8,15,16] The main advancement includes preservation of the local vascularity, a small incision wound, and adequate stabilization. These favorable factors have enhanced fracture repair and achieved a comparatively high success rate compared to other intramedullary devices. The side plate used with SCSs has no function.[22] Therefore, the stability in a segmental comminuted fracture may be insufficient. More-ideal ways of resolving this are to use a longer plate and to more strictly restrict weight-bearing.[1-4]

Traditionally, subtrochanteric fractures were categorized using the Seinsheimer classification.[1,2,10] The upper boundary of type I is the upper margin of the lesser trochanter. Thus, most subtrochanteric fractures can be treated with first-generation nails.[2,12] However, in those fractures with inter- and subtrochanteric involvement, second-generation nails or Gamma nails, for which the proximal screw is inserted into the femoral head, must be used. When using SCSs to stabilize subtrochanteric fractures, the Russell-Taylor classification is likely more suitable. As for the AO (Arbeitsgemeinschaft fur Osteosynthesefragen) classification, its application is similar to the Seinsheimer classification.[10,12]

For Russell-Taylor type II fractures, the lateral cortex of the greater trochanter is required to prevent the upper fragment from sliding down too far. Thus, comminuted fractures in the greater trochanter should be carefully evaluated.[23] Our policy is that these fractures be treated with nail devices, and those patients were excluded from this study.

In conclusion, compared to other techniques, indirect reduction with SCS stabilization is a feasible method for treating acute subtrochanteric fractures. However, because plate insertion normally requires a large dissecting wound and biomechanically the tension band principle might not be applicable, there might be greatly increased complications with extensively comminuted fractures. Accordingly, if this technique is used for carefully selected fractures, high success rates can be expected.

REFERENCES

1. DeLong WG. Subtrochanteric fractures. In: Bulcholz RW, Heckman JD, eds. Rockwood and Green's Fractures in Adults. 5th ed. Vol. 2. Philadelphia, PA: Lippincott Williams & Wilkins, 2001:1665-81.
2. LaVelle DG. Fractures of hip. In: Canale ST, ed. Campbell's Operative Orthopedics. 10th ed. Vol. 3. Philadelphia, PA: Mosby, 2003:2873-938.
3. Thakur. The Elements of Fracture Fixation. New York: Churchill Livingstone, 1997:105.
4. Obrant K. Management of Fractures in Severely Osteoporotic Bone. London: Springer, 2000:163.
5. Doppelt SH. The sliding compression screw -- today's best answer for stabilization of intertrochanteric hip fractures. Orthop Clin North Am 1980;11:507-23.
6. Wu CC, Shih CH. Biomechanical analysis of the dynamic hip screw in the treatment of intertrochanteric fractures. Arch Orthop Trauma Surg 1991;110:307-10.
7. Tencer AF, Johnson KD. Biomechanics in Orthopedic Trauma. Philadelphia, PA: JB Lippincott, 1994:249.
8. Kinast C, Bolhofner BR, Mast JW, Ganz R. Subtrochanteric fractures of the femur. Results of treatment with the 95 degrees condylar blade-plate. Clin Orthop 1989;238:122-30.
9. DeLee JC, Heckman JD, Lewis AG. Partial fibulectomy for ununited fractures of the tibia. J Bone Joint Surg [Am] 1981;63:1390-5.
10. Seinsheimer F. Subtrochanteric fractures of the femur. J Bone Joint Surg [Am] 1978;60:300-6.
11. Karlstrom G, Olurud S. Fractures of the tibial shaft: a critical evaluation of treatment alternatives. Clin Orthop 1974;105:82-111.
12. Wu CC, Shih CH, Lee ZL. Subtrochanteric fractures treated with interlocking nailing. J Trauma 1991;31:326-33.
13. Nordin M, Frankel VH. Biomechanics of the hip. In: Nordin M, Frankel VH, eds. Basic Biomechanics of the Musculoskeletal System. 2nd ed. Philadelphia, PA: Lea & Febiger, 1989:135-51.
14. Wood GW II. General principles of fracture treatment. In: Canale ST. Campbell's Operative Orthopedics. 10th ed. Vol. 3. Philadelphia, PA: Mosby, 2003:2669-723.
15. Kesemenli C, Subasi M, Necmioglu S, Kapukaya A. Treatment of multifragmentary fractures of the femur by indirect reduction (biological) and plate fixation. Injury 2002;33:691-9.
16. Huang HT, Huang PJ, Su JY, Lin SY. Indirect reduction and bridge plating of supracondylar fractures of the femur. Injury 2003;34:135-40.
17. Reynders PA, Stuyck J, Rogers RK, Broos PL. Subtrochanteric fractures of the femur treated with the Zickel nail. Injury 1993;24:93-6.
18. Miedel R, Ponzer S, Tornkvist H, Soderqvist A, Tidermark J. The standard Gamma nail or the Medoff sliding plate for unstable trochanteric and subtrochanteric fractures. A randomised, controlled trial. J Bone Joint Surg [Br] 2005;87:68-75.
19. Roberts CS, Nawab A, Wang M, Voor MJ, Seligson D. Second generation intramedullary nailing of subtrochanteric femur fractures: a biomechanical study of fracture site motion. J Orthop Trauma 2002;16:231-8.
20. Cheng MT, Chiu FT, Chuang TY, Chen CM, Chen TH, Lee PC. Treatment of complex subtrochanteric fracture with the long gamma AP locking nail: a prospective evaluation. J Trauma 2005;58:304-11.
21. Bostman O, Varjonen L, Vainionpaa S, Majola A, Rokkanen P. Incidence of local complications after intramedullary nailing and after plate fixation of femoral shaft fractures. J Trauma 1989;29:639-45.
22. Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of locked plates and screws. J Orthop Trauma 2004;18:488-93.
23. Im GI, Shin YW, Song YJ. Potentially unstable intertrochanteric fractures. J Orthop Trauma 2005;19:5-9.

以間接式復位及壓縮式鋼釘固定去治療股骨轉子下骨折

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背 景： 股骨轉子下骨折具有獨特的性質；迄今，仍沒有任何單獨的治療器材，可被一致地認定絕對會比其他器材更優越。壓縮式鋼釘手術技術上較單純，一般骨科醫師也較熟練。因此，我們報告用間接式復位，並以壓縮式鋼釘固定，去治療股骨轉子下骨折的經驗及心得，以作爲未來的選用依據。

方 法： 131 處急性股骨轉子下骨折但無廣泛性股骨幹的延伸，被以此種手術方式治療；依骨折型態將其分成四組，以評估其成功率。手術時，在滑動螺釘放置於股骨頭後，而接著裝置外側鋼板前，不要去挖掘骨折處，鋼板僅限於架設跨越。對遠端骨段，至少需四個皮質螺釘固定。術後，限制負重的活動可及早進行。

結 果： 113 處股骨轉子下骨折，被複查平均有 22 個月（期間爲 12-38 個月）。得到的癒合率爲 94.7%，而癒合時間平均爲 3.8 (2.5-8) 個月。各組間，未有統計學上差異。併發症包括有 6 處 (5.3%) 骨折不癒合：其中一處 (0.9%) 合併深部感染，有兩處 (1.8%) 合併內置器材失效。

結 論： 與其他手術方法比較，用間接式復位，並以壓縮式鋼釘固定，是一項治療急性股骨轉子下骨折的卓越的方法。但是，由於裝設鋼板需要很大的傷口；加上生物力學上，張力帶原則可能無法被運用。在治療廣泛粉碎性骨折時，併發症可能會大大增加。據此推理，此種手術方式應該用在被選擇後的案件，高成功率當可預期。
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關鍵字：間接式復位，壓縮式鋼釘，股骨轉子下骨折。

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